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For: COMMUNICATIONS ARCHITECTURE FOR AN INDUSTRIAL PROCESS CONTROL SYSTEM AND A CORRESPONDING PROGRAMMED UNIT

DECLARATION

I, Andrew Scott Marland, of 35, avenue Chevreul, 92270 BOIS COLOMBES, France, declare that I am well acquainted with the English and French languages and that the attached translation of the convention document relating to French patent application number **98/09381** as originally filed on July 22, 1998 is a true and faithful translation of that document.

All statements made herein are to my own knowledge true, and all statements made on information and belief are believed to be true; and further, these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any document or any registration resulting therefrom.

Date: January 24, 2003

Andrew Scott Marland

COMMUNICATIONS ARCHITECTURE FOR AN INDUSTRIAL PROCESS CONTROL SYSTEM AND A CORRESPONDING PROGRAMMED UNIT

The invention relates to information communications architecture designed more particularly to be installed in an industrial process control system so as to enable digitized information to be transmitted in time shared manner between programmed operating units of the system. It also relates to a programmed operating unit and in particular to a process interface unit, known as a site unit, for an industrial process control system including such communications architecture.

As is known, managing an industrial process control system involves the presence of communications architecture in order to transmit information between the various programmed operating units that can act in the control of the process, so that the information is transmitted in a manner well suited to the various needs encountered. Such an architecture is commonly made up of one or more "industrial" local area networks organized around one or more bus-type links.

It is conventional in such systems to use the links in time shared manner for transmitting information between the programmed operating units. It is common in the field of industrial process control to have very strict transmission constraints for certain information. That involves implementing "deterministic" local area networks which are organized to make it possible to comply completely with the time constraints for transmitting information for which such constraints are necessary.

It is then known to enable information whose transmission is subject only to relatively flexible constraints in terms of urgency to make use of the lapses of time that are left available on a more or less regular basis by the priority information which is subject to constraints that are more severe.

In many operating cases, it is advantageous to be able to access, at will and without there necessarily being any urgency, information contained in a memory of any one of the programmed operating units of a system, e.g. by means of another programmed unit or of a computer, via the communications architecture of the system, and regardless of the location of said other unit or of said computer relative to the system.

In particular, when the operation of a system involves a wide variety of equipment involving various users taking action that is not necessarily plannable, it is advantageous for those users to be able to access easily the information that they need, via the communications architecture of the system, and optionally from the outside, whenever such information is stored accessibly by a programmed operating unit of the system.

Such access must preferably be possible for users who can differ widely. One known system thus makes provision to use a communications architecture that uses an information access technique that is implemented more particularly in the context of the Internet.

For that purpose, the information that is available in the programmed operating units and in particular the information that has been collected via the communications architecture of the system, is inserted into HTML pages installed in a programmed operating unit of the system that is constituted by a dedicated computer in which an HTTP server is installed. That computer is, for example, connected to an external network 0 which uses the Internet techniques, or even to the Internet itself. Any user who has access to a suitably-equipped computer assumed, in that example, to be connected to the network 0, or who has access to a functionally-equivalent programmed unit of the system, can then become acquainted with the information contained in the HTML pages, stored in the dedicated computer.

However, that solution is not entirely satisfactory in particular as regards how up-to-date the stored information is. Unfortunately, that can be crucial in a system in which certain items of equipment and in particular certain site units are used in real time and must not be disturbed during the control of the process.

The invention therefore provides a time-shared communications architecture for communicating digitized information for an industrial process control system, which architecture is organized around at least one industrial local area network conveying deterministic traffic between various programmed operating units, in particular site units situated at a process interface level, which programmed operating units process and store information which can be accessed by at least one other unit via said architecture.

According to a characteristic of the invention, said architecture includes programmed operating units and in particular site units individually including HTTP servers so as to be capable of sending optionally interactive computer documents in response to requests received from another unit of the system or from a computer, in particular external to the system, equipped with an HTTP/TCP/IP protocol stack and acting as a customer, in the context of messaging traffic making use of the transmission possibilities left available at the level of the industrial local area network by the deterministic traffic.

According to another characteristic of the invention the architecture is constituted in a manner such that units are organized in one or more clusters around at least one industrial local area network which is specific to a cluster and which connects the units of a cluster to one shared unit, optionally serving as a gateway or as a router to another industrial local area network serving at least one other programmed unit of a higher level of the architecture, in particular a supervision unit and/or

optionally a unit serving as a gateway or router to an external communications network, so that the HTTP server of a cluster unit equipped with such a server responds with an optionally interactive computer document if a request is addressed to it, via at least one of the networks, by another unit or by a computer, in particular external to the system, equipped with an HTTP/TCP/IP protocol stack, when the request concerns inserting or extracting parameters and/or variables stored at the unit that includes said server.

According to another characteristic of the invention, each local area network specific to a cluster transmits IP datagrams, corresponding to the client requests coming from or via the shared unit to the units of the cluster, and corresponding to the responses supplied by said clusters, in time intervals left free for messaging traffic by the deterministic traffic of data provided in real time at said cluster network level.

The invention also proposes a programmed operating unit for an industrial control system provided with a time-shared communications architecture for communicating digitized information, which architecture includes at least one industrial local area network supporting deterministic traffic to which said unit is connected so as to be able to communicate with at least another programmed unit.

According to a characteristic of the invention, the unit includes a server and therefore an HTTP/TCP/IP stack for responding to requests as they arise, in particular requests for inserting or for extracting parameters and/or variables stored by said unit and transmitted by said network(s), in the context of messaging traffic making use of the transmission possibilities left available by the deterministic traffic.

The invention, its characteristics, and its advantages appear more clearly from the following

description given with reference to the following list of figures, in which:

Figure 1 is a diagram summarizing the principle of a known communications architecture for an industrial system;

Figure 2 is a diagram summarizing the principle of a communications architecture of the invention; and

Figure 3 is a simplified diagram showing an example of a communications architecture of the invention for an industrial control system.

The prior art communications architecture that is shown in Figure 1 is organized to enable information to be interchanged between programmed operating units 1, 2, 3 of an industrial process control system made up of a plurality of monitoring/control devices, including, for example, site devices such as sensors 4 and actuators 5. These devices are controlled by programmed operating units represented in that example by units 2 that are assumed to deliver and/or receive information relating to the operations, in particular control and measurement operations, performed by the devices that they control. The operating units, such as the units 2, communicate as a function of needs firstly with the devices that they control, and secondly with other units of higher level, such as 1 and 3, which are, in particular, assigned the task of supervising the industrial control system. The communications are set up via communications means 6 of the architecture, to which means the various units are connected more or less directly. As developed below, the communications means 6 are conventionally of the industrial local area network type.

Communications means 6' make it possible to connect the monitoring/control devices of the system to the operating units that control them, which communications means are optionally also of the industrial local area network type.

As indicated above, provision is made to implement time shared operation of the links in the communications means 6 and 6' so as to transmit information between the programmed operating units and between said units and the control devices, by enabling the information whose transmission is subjected only to constraints that are relatively flexible as regards urgency to make use of the lapses of time that are left available on a more or less regular basis by the information which is subject to more severe time constraints.

In order to make it possible to access information from outside the system, a server 7 of the HTTP type is provided in a unit of higher level, such as 1, which stores the information that is supplied to it by the other units and by the site devices in order to be able to insert it into HTML-format pages to which access is possible by means of a computer equipped to be able to access such pages. The computer (not shown) is, for example, connected to the unit 1 via a network 0 and for example via the Internet.

A user can thus access information, such as parameters or variables specific to the system, which are stored in the unit 1. The user may optionally supply information to the system, e.g. updating information, in particular if the user has a computer equipped to be able to act as an HTTP server.

As indicated in the preamble of this Application, that solution is not fully satisfactory insofar as all of the information to be accessible in that way must be stored and updated at the unit 1, and insofar as it is possible for that information to be inexact, in particular when information characteristic of a change that has taken place at another unit or at a site device has not yet reached the unit 1 and when the HTML page in which it is to appear is supplied to a requesting user prior to updating. In addition, the use of the unit 1 as a storage intermediary that must be updated continuously

induces an incessant information traffic which it is advantageous to avoid in networks that constitute the backbone of the communications means 6 and 6'.

The invention therefore proposes to modify the communications architecture of an industrial control system in the manner shown diagrammatically in Figure 2.

This architecture is designed to provide information interchange between programmed operating units of an industrial process control system that includes a plurality of monitoring/control devices 4, 4', 5 controlled as described above by units that are referenced 8 in this example and that differ from the units 2 by the means with which they communicate with the other units. At least some of the units, and optionally at least some of the monitoring/control devices, such as 4', include a server 9, of the HTTP type. In most cases, this server is relatively rudimentary insofar as, in particular, it does not generally need to include a specific data base for storing the information that it can receive and transmit, in particular when such data is already stored locally.

Such information is taken into account by the server 9 of the unit, which stores it, so that it can then be incorporated into transmitted computer documents that are optionally interactive, e.g. into HTML pages. For example, the information may correspond to modifications in parameters or to changes in variables that are more or less complex.

Naturally, other programmed operating units of the system can be provided with a server 9, of the HTTP type, that is more or less elaborate depending on needs, as symbolized at a higher-level unit 10 which is represented in this example by two units 10 and 11.

The servers 9 have individual addresses of the Internet type which make it possible for a user to have access thereto by means of a suitably-programmed unit of the system or by means of a computer equipped with

software and hardware suitable for being capable of behaving like an Internet customer. The customer unit or the computer acting as a customer is put in communication with a server of another unit and in particular a site unit via the set of communications means 6 included in the architecture and optionally via the Internet to which said set of communications means is then connected by a unit acting as a gateway.

To this end, the various programmed operating units of the industrial process control system that include HTTP servers are provided with communications couplers compatible with the HTTP/TCP/IP protocols and services in addition to the standard protocols and services of the local area network(s) used. They are thus capable of transmitting and receiving IP datagrams conveyed by said network(s), without disturbing the deterministic information interchange related to real-time process control.

Figure 3 shows a non-limiting example of an industrial process control system organized on the basis of a modular monitoring-control system for industry, e.g. the Applicant's ALSPA 8000 system. That system includes a plurality of programmed operating units, each of which is conventionally organized around at least one processor, a set of read-only and or read/write memories, and auxiliary equipment such as, in particular, input/output couplers. Such a system incorporates three levels of operational functions corresponding successively to a process supervision and control level, to a process automation intermediate level, and to a process input/output level, in which levels various units are distributed.

The programmed operating units of the process supervision and control higher level are represented in this example by a process supervision and control operator platform 12, a supervision operator main station 13, a process computer 14, a unit 15 serving as a router

or as a gateway for communicating with an external computer network 0, e.g. an Intranet or the Internet.

The programmed operating units of the process automation intermediate level are, in this example, represented by automatic controllers 17, 17', 17" which, in this example, are assumed to differ functionally, one being assumed, for example, to host sequential automation applications, another being a programmed power electronics controller, etc. The units may also be organized to be suitable for being used as gateways, which then perform protocol conversions, or as routers between local area networks 19, 19', or 19" and 20 included in the communications architecture.

The site programmed operating units situated at the interface with the process may be of various types. In this example, they are represented by input/output units 18 making it possible to put conventional sensors and/or actuators in communication with a suitable controller for controlling the level of automation of the process, by "intelligent" sensors and/or actuators 18', by units 18" for regulating and monitoring power conversion electrical equipment 18", by control units 18"' for controlling variable speed drive units, and by operator local stations 18"", etc.

It should naturally be understood that the units mentioned above are indicated merely by way of example, and that the above-indicated number of levels may optionally be reduced by grouping together functions of one level with functions of another level in operating units organized appropriately.

In the example considered, the communications architecture of the industrial process control system is assumed to be made up of deterministic industrial local area networks designed to accommodate both priority deterministic traffic for transmitting variables, and also event-based or "messaging" traffic. For example, the architecture may be based on implementing the

standardized WORLDFIP network constituted by the Applicant's F8000 network.

Through the industrial local area networks, the operating units of the system are connected firstly to one another and optionally to the outside of the system, and secondly to various devices (not shown) in particular for monitoring/controlling the system, and to which certain units are physically connected by links L.

The operating units can be of a wide variety of types, both as regards their natures and their operating modes, and they are not developed herein insofar as they have only an indirect relation to the invention.

In the example considered with reference to Figure 3, provision is made for the site units 18, 18', 18", 18"', 18"" to be organized in one or more clusters around at least one individual cluster local area network such as 19, 19', or 19", generally referred to as a "site bus". In this example, the cluster network is connected to a programmed operating unit of intermediate level assumed, for example, to be constituted by a controller 17, 17', or 17".

Each of the intermediate units serves, in this example, as a gateway or as a router assigned to putting the cluster site units to which it is connected via one of the cluster networks in communication with the higher-level units to which it is connected via a higher-level industrial local area network 20 commonly referred to as a "cell bus" or as a "control room bus".

The units are individually provided with HTTP servers, and have Internet-type addresses, the communications couplers that they include comply with the HTTP/TCP/IP protocols and services in addition to the standard services and protocols of the industrial local area networks used. The units are thus capable of transmitting and receiving IP datagrams which are, for example, encapsulated in messages conveyed in the context of standard messaging traffic, via the local area

networks such as 19 and 20, without disturbing the deterministic traffic for interchanging variables that is conveyed via the networks. The datagrams may also be conveyed in the context of traffic replacing or adding to the standard messaging traffic, without disturbing the deterministic traffic. This thus makes it possible for at least one customer unit to address them so as to cause the information they store to be communicated to it so as to modify some of said information, without disturbing the real-time operation of the control system.

Such access takes place transparently via one of the intermediate units serving as a gateway for the site units of the same cluster. As indicated above, a user can access a server 9 of a unit, via a duly-programmed customer operating unit of the system and more particularly via a higher-level operating unit, through local area networks 19, 20, and through one of the intermediate units. The user can act from a customer unit constituted, for example, by an operator main station 13, or from a duly-equipped computer of the system or that communicates via the external computer network 0.

A server that receives a request from a unit acting as a customer responds with an optionally-interactive computer document. The customer unit necessarily has an HTTP/TCP/IP protocol stack available so that it can firstly address its request and secondly take into account the information received in the form of a computer document from the server that it has addressed, the information being, for example, included in an HTML page. In particular, this makes it possible to insert or to extract parameters and/or variables, via a server 9, when said information is stored by the site unit that contains said server.

In the system considered herein, the local area network, such as 19, of a cluster of units conveys IP datagrams corresponding firstly to the customer/server

requests coming from or via the shared unit, such as 17, to the servers of the units of the cluster, and secondly to the responses from said servers.

As is known, the use of the HTTP protocol makes it possible to reduce the time of use of the resources (process and socket) to a value that is very low because there is no session established between a customer unit and a server, and because the TCP/IP connection is interrupted, as soon as the customer unit has received the HTML document that it has requested of the server. The use of these resources by a customer unit thus always remains of very limited duration, which is particularly advantageous as regards how busy the transmission means included in a communications architecture of industrial facilities are. Naturally, the HTML pages produced at the level of a server of a site unit may contain hypertext links enabling a customer unit to go from one server to another in predetermined manner, if necessary.

CLAIMS

1/ A time-shared communications architecture for communicating digitized information for an industrial process control system, which architecture is organized around at least one industrial local area network (6) conveying deterministic traffic between various programmed operating units (8, 10, 11), in particular site units (8) situated at a process interface level, which programmed operating units process and store information which can be accessed by at least one other unit (10, 11) via said architecture, said architecture being characterized in that it includes units (8, 10) individually including servers (9) of the HTTP type so as to be capable of sending optionally interactive computer documents in response to requests received from another unit (11) of the system or from a computer, in particular external to the system, equipped with an HTTP/TCP/IP protocol stack and acting as a customer, in the context of messaging traffic making use of the transmission possibilities left available by the deterministic traffic of the network(s).

2/ An architecture according to claim 1, for an industrial process control system, in which units (18) are organized in one or more clusters around at least one industrial local area network (19) which is specific to a cluster and which connects the units of one cluster to one shared unit (17), optionally serving as a gateway or as a router to another industrial local area network (20) serving at least one other unit (14, 15) of a higher level of the architecture, in particular a supervision unit and/or a unit serving as a gateway to an external communications network (0), so that the HTTP server of a unit or of a monitoring/control device (4') of the system equipped with such a server responds with an optionally interactive computer document if a request is addressed to it, via at least one of the networks, by another unit

or by a computer, in particular external to the system, equipped with an HTTP/TCP/IP protocol stack and acting as a customer, when the request concerns inserting or extracting parameters and/or variables stored at the unit that includes said server.

3/ An architecture according to claim 2, in which each local area network specific to a cluster transmits IP datagrams, corresponding to the client requests coming from or via the shared unit to the units of the cluster, and corresponding to the responses supplied by said clusters, in time intervals left free for messaging traffic by the deterministic traffic of data provided in real time at said cluster network level.

4/ A programmed operating unit for an industrial process control system provided with a time-shared communications architecture for communicating digitized information, said architecture including at least one industrial local area network (19, 20) which supports deterministic traffic and to which said unit is connected so as to be able to communicate with at least another programmed unit, the programmed operating unit being characterized in that it includes a server (9) of the HTTP type, and therefore an HTTP/TCP/IP stack for responding to requests as they arise, in particular requests for inserting and/or for extracting parameters and/or variables stored by said unit and transmitted by said network(s), in the context of messaging traffic making use of the transmission possibilities left available by the deterministic traffic.